Use of sewage ponds by birds in Khartoum State, Sudan, and their influence on bird distribution in the region

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L'utilisation de bassins d'eaux usées par les oiseaux à Khartoum, Soudan, et les effets sur la distribution des oiseaux dans la région. Nous avons recensé 139 espèces d'oiseaux dans quatre bassins d'eaux usées à Khartoum, au Soudan. La Foulque caronculée *Fulica cristata* a été observée pour la première fois dans ce pays où elle compte une population nicheuse. La Sarcelle hottentote *Spatula hottentota* et la Talève sultane *Porphyrio porphyrio*, connues auparavant d'une seule mention pour chacune d'elles, sont également représentées par des populations nicheuses résidentes. La reproduction de la Gallinule poule-d'eau *Gallinula chloropus* et du Gravelot à triple collier *Charadrius tricollaris* a été notée pour la première fois dans le pays. La Rousserolle stentor *Acrocephalus stentoreus* a été trouvée au sud et le Tisserin gendarme *Ploceus cucullatus* au nord de leur aires de répartition connues. L'Ibis sacré *Threskiornis aethiopicus* hiverne en grand nombre, ce qui n'avait pas encore été rapporté. Une liste annotée des espèces recensées est présentée ainsi que des notes supplémentaires pour celles dont le statut a changé. Certaines de ces dernières possèdent des populations viables dans des petites parcelles d'habitat d'eaux usées. La manière dont les bassins d'eaux usées fournissent un nouvel habitat pour les oiseaux est examinée, ainsi que les implications potentielles pour la conservation des espèces afrotropicales et paléarctiques qui utilisent ces habitats et étendent ainsi leurs aires de distribution le long du Nil.

Summary. We recorded 139 bird species at four sewage sites in Khartoum State, Sudan. Red-knobbed Coot *Fulica cristata* was observed for the first time in Sudan, with a resident breeding population. Hottentot Teal *Spatula hottentota* and Purple Swamphen *Porphyrio porphyrio*, both previously known only from single records, were also revealed to have resident breeding populations. Common Moorhen *Gallinula chloropus* and Three-banded Plover *Charadrius tricollaris* were recorded breeding for the first time in the country. A southerly range extension was noted for Clamorous Reed Warbler *Acrocephalus stentoreus* and a northerly range extension for Village Weaver *Ploceus cucullatus*. Sacred Ibis *Threskiornis aethiopicus* was found to have a large, hitherto unrecorded, wintering population. An annotated checklist is presented of all species recorded, with additional notes for those showing a change in status. Some of these have viable populations in very small patches of sewage habitat. We discuss how sewage ponds have provided new habitats for birds, and the potential conservation implications for Afrotropical and Palearctic species using such areas, thereby extending their ranges along the Nile.

Khartoum State lies at the confluence of the Blue and White Niles, from where the main River Nile flows north to Egypt. These three rivers separate the three largest cities in Sudan: Khartoum, Bahri and Omdurman, which together comprise an urban centre of *c.*7 million people (Alsalman & Ali 2011). Away from the immediate vicinity of the Nile, the habitat of Khartoum State is *Acacia* desert scrub (Cave & MacDonald 1955). The region has distinct wet (May–September) and dry seasons (Nikolaus 1987). Shortly after the wet season ends, most pools have dried up, leaving very little standing water. During the dry season, sewage ponds provide the only extensive still-water wetlands in the area. South of Khartoum, the Gezira Scheme provides a network of irrigation ditches between the Blue and White Niles (Plusquellec 1990), but north of Khartoum there is little irrigation far from the banks of the Nile.

There have been relatively few publications on the birds of Sudan. The only field guide to cover the whole country was published in 1955 (Cave & Macdonald 1955), and since then the only major publication was a distribution atlas of Sudan's birds (Nikolaus 1987). Robertson (2001) discussed the inland wetlands of Sudan as 'enormously important for huge numbers of many species of waterbird', but we are aware of no recently published studies of wetland birds in Sudan, and none that specifically discusses the use of sewage ponds. These works include South Sudan, which became independent from Sudan in 2011 (Christopher 2011). All references to

'Sudan' hereafter refer to the current borders of the Republic of Sudan.

Much of the wastewater in Khartoum State is disposed of in pit latrines and septic tanks, but two large sewage treatment plants using stabilisation ponds exist at El Hag Yousif in Bahri, constructed in 1982 and expanded in 1990, and at Soba, south of Khartoum, implanted in 1971 (Maki 2010). Waste stabilisation ponds are shallow basins enclosed by earth embankments in which sewage is treated by natural methods using algae and bacteria. They are a common system of sewage treatment in many developing countries, and are particularly suitable in warm climates if sufficient land is available (Mara 2003), making them ideal for use in Sudan. Sewage treatment sites are recognised as important areas for birds (e.g. Glue & Bodenham 1974, BirdLife International 2014). This study aims to provide information on birds using sewage ponds in Khartoum State, with particular reference to those species that appear to have changed their status since the publication of Nikolaus (1987).

Study sites and Methods

Observations were made at four sewage treatment plants that use stabilisation ponds. Khartoum sewage treatment works (15°30'07"N 32°32'49"E) has eight ponds covering a total of *c.*40 ha, the two largest each *c.*15 ha, with approximately 4.3 km of perimeter edged by *Phragmites* reeds *c.*2–3 m wide. The sewage treatment works at Bahri (15°40'04"N 32°36'28"E) comprise 15 ponds covering *c.*120 ha, the largest *c.*30 ha, with approximately 9.1 km of perimeter edged by reeds, in places 10–15 m wide. In both Khartoum and Bahri, some of the smaller ponds were empty throughout the study. The small sewage site serving Soba Hospital (15°30'40"N 32°37'55"E), just south of Khartoum, has 11 small ponds with a total area of *c.*2 ha, the ponds being employed on a rotational basis such that some are empty, some have open water and some are filled with reeds at any given time. A small sewage treatment pond serving Omdurman Islamic University (15°34'19"N 32°27'25"E) has *c.*1–2 ha of permanent open water, which floods to form a larger area during the wet season. About half of the site at Omdurman is reed-covered. At all four sites, reeds are cut for use in roofing. Omdurman does not have any large sewage treatment works equivalent to those in Khartoum and Bahri, although there are plans for one (Maki 2010).

We visited Soba Hospital 23 times in April 2012–February 2015, Khartoum seven times in November 2013–December 2014, Bahri 28 times in November 2013–May 2015, and Omdurman twice in May 2014 and January 2015, with the majority of visits between mid August and early June. Mist-nets were employed at Bahri (24 times), Khartoum (once) and Soba (twice) as part of a separate study of Northern Masked Weavers *Ploceus taeniopterus* and Cinnamon Weavers *P. badius* (Jenner in prep.). Observations were not standardised and effort was not consistent on each visit, especially during mist-netting activities. High reeds surrounding many of the ponds limited visibility and some areas at Bahri and Khartoum could not be accessed at all. All counts are therefore conservative, especially of those species inhabiting reedbeds. Most open-water species, such as ducks, grebes and coots, tended to occupy particular ponds, so effort was concentrated on these areas, where visibility was usually better. Observations from open scrub surrounding the ponds are included, but less effort was made in this habitat, so many landbird species using sewage sites will have been under-recorded.

Results

We recorded 139 bird species at the four study sites (see Appendix 1). Of these, 71 were residents in the area, with 41 either confirmed to breed or assumed to be breeding within the grounds of the sewage sites, and the remaining 30 being probably local residents recorded flying over or passing through the site, but unlikely to use the areas regularly. Fifty-one were considered solely winter visitors from the Palearctic, with several resident populations supplemented by winter migrants. Another ten were Palearctic migrants on passage. Seven were intra-African migrants breeding locally, although none was confirmed to breed at the sewage sites. In many cases, we have had to assume status, except for those species for which breeding was confirmed. Our assessment of the status of many species is based on our experience from hundreds of days in the field at other locations in the region (most published on birdingsudan.blogspot.com).

Notes on selected species

The following notes provide details on species whose status appears to have changed considerably since the publication of Nikolaus (1987).

Little Grebe *Tachybaptus ruficollis*

Abundant winter visitor, with breeding pairs present at Bahri, Khartoum and Soba Hospital. Described by Nikolaus (1987) as a seasonal migrant in October–April, breeding only in the west of the country.

Sacred Ibis *Threskiornis aethiopicus*

Observed breeding in the wet season at Bahri (Fig. 1). Also present throughout the dry season, including on every visit to Bahri (peaking at *c.*300 in early February 2014), with one sighting at Khartoum and two at Soba Hospital. Observed on many occasions at other locations near the rivers and occasionally over urban areas. Nikolaus (1987) stated that the species is 'only a breeding visitor to the north from May to October'. It is unlikely that this conspicuous species would have gone unnoticed previously, which suggests that our dry-season records represent a change in its status.

Hottentot Teal *Spatula hottentota*

Recorded in all months at all four sewage sites on most visits; first recorded at Soba Hospital on 6 April 2012. The max. count was 48 at Khartoum (September 2014), with high counts at all four sites, including the small areas at Soba Hospital (max. 42, October 2012) and Omdurman (max. 30, January 2015). On 31 January 2015, we recorded 15 small ducklings from three broods at Omdurman (Fig. 2) and on 11 February 2014, we photographed a pair at Khartoum with a single young that was about half the size of the adults. All our records are from sewage sites, but Dewilde (2012) photographed three birds on the White Nile at Al Dabbaseen Bridge near Omdurman on 11 May 2012, indicating that the species also uses the river at least occasionally. Nikolaus (1987) mentioned just one record within the current borders of Sudan, at Khartoum in spring 1981, with another from what is now South Sudan. There has clearly been a significant northerly range expansion in recent years.

Southern Pochard *Netta erythrophthalma*

Recorded regularly at Bahri and Khartoum in November 2013–March 2015 (all records between August and early March), with max. 11

Figure 1. Sacred Ibis *Threskiornis aethiopicus* (right) and Glossy Ibis *Plegadis falcinellus*, Bahri Sewage Ponds, Sudan, 17 October 2014 (Tom Jenner)

Ibis sacré *Threskiornis aethiopicus* (à droite) et Ibis falcinelle *Plegadis falcinellus*, bassins d'eaux usées de Bahri, Soudan, 17 octobre 2014 (Tom Jenner)

Figure 2. Hottentot Teal *Spatula hottentota* with chicks, Omdurman Islamic University, Sudan, 31 January 2015 (Tom Jenner)

Sarcelle hottentote *Spatula hottentota* avec poussins, Université islamique de Omdurman, Soudan, 31 janvier 2015 (Tom Jenner)

individuals. Described by Nikolaus (1987) as a rare vagrant, but our records suggest it is a regular winter visitor in small numbers.

Purple Swamphen *Porphyrio porphyrio*

The Afrotropical subspecies *P. p. madagascariensis* was observed at all sites in all months, with our first record at Soba Hospital on 6 April 2012 (Fig. 3). Our only record away from sewage habitat was a conservative count of 125 feeding in open flooded fields between the White Nile and Sunt Forest, near central Khartoum, in May 2015, although none had been observed there on seven previous visits. We observed immatures at Khartoum sewage ponds on 12 September and at Sunt Forest on 22 May. Nikolaus (1987) reported just one record from Sudan, at Kosti, *c.*260 km south of Khartoum, with none from South Sudan. This subspecies breeds in Egypt and has done so since antiquity (Goodman & Meininger 1989). It was not recorded in the Nile Valley south of Cairo until the late 1970s, but has since spread throughout the complete length of the Egyptian Nile Valley as a result of the spread of reedbeds following the construction of Aswan Dam (Goodman & Meininger 1989). It is unclear whether the population in Khartoum State is recent or was previously overlooked. However, it is difficult to believe this species could persist in the region without man-made wetlands.

Figure 3. Purple Swamphen / Talève sultane *Porphyrio porphyrio*, Soba Hospital, Sudan, 6 April 2012 (Tom Jenner)

Common Moorhen *Gallinula chloropus*
Nikolaus (1987) described it as a passage migrant and winter visitor between September and February. We found the species to be a common year-round resident at all four sites. It was especially common at Khartoum, where hundreds were usually present. We photographed small chicks in September 2014 and regularly saw immatures between September and February at all four sites. It is a common breeder in neighbouring Egypt (Goodman & Meininger 1989).

Red-knobbed Coot *Fulica cristata*
First recorded at Khartoum sewage treatment works in November 2013 and present during all visits to this site, with max. 44 on 24 January 2014. On the same day, a pair was photographed with two medium-sized chicks that were probably 2–3 weeks old (Fig. 4). On 10 February 2014, at the same site, we observed three family groups, two with two juveniles and one with a single juvenile. An adult in breeding plumage was observed at Bahri on 4 April 2014. We are aware of no previous reports of this species in Sudan. Nikolaus (1987) made no mention of it and only refers to Common Coot *Fulica atra*, which he described as an uncommon winter visitor. It is unclear whether Red-knobbed Coot has expanded its range into the country or if it was previously overlooked, as the two coot species can be confused in non-breeding plumage. We recorded up to six Common Coots throughout our study at Bahri, between mid November and early March, and a single on the White Nile in Khartoum on 2 December 2011, but never saw the two species together.

Three-banded Plover *Charadrius tricollaris*
Observed at Soba Hospital on seven occasions in three consecutive years, in February, April–June and October, with two present on three occasions (Fig. 5). On 14 April 2012, a bird in *Acacia* scrub *c.*20 m from the nearest water behaved as if it had a nest nearby, although none was found. It kept landing nearby and walking away as if trying to distract the observer. Such behaviour is usually considered proof of breeding (BTO 2014). The species was first recorded in Egypt in 1993, and it was confirmed breeding there in 2009 (Jiguet *et al.* 2011).

Slender-billed Gull *Larus genei*
Two photographed on 4 April 2014 at Bahri. We have other records away from sewage sites, including a group of six photographed migrating

Figure 4 (below). Red-knobbed Coot *Fulica cristata* with chicks, Khartoum Sewage Ponds, Sudan, 11 February 2014 (Tom Jenner)

Foulque à crête *Fulica cristata* avec jeunes, bassins d'eaux usées de Khartoum, Soudan, 11 février 2014 (Tom Jenner)

Figure 5 (right). Three-banded Plover / Gravelot à triple collier *Charadrius tricollaris*, Soba Hospital, Sudan, 25 October 2012 (Tom Jenner)

north along the White Nile past Tuti Island on 24 February 2012 (Fig. 6), a single moving north over the Blue Nile south of Khartoum on 25 March 2012, and four groups totalling *c.*40 individuals heading north over the White Nile at Jebel Aulia on 21 February 2015. We also have two additional sightings of distant groups of birds migrating along the White Nile that were almost certainly this species, and there is a record of two seen at Um Shugeira, Khartoum, March 2012 (Woods & Faki 2012). Nikolaus (1987) reported only one inland record, from Khartoum in spring 1980. It is probably regular in Khartoum State on passage. In Egypt the species is generally confined to saline habitats. However, changes in agriculture during much of the 20th century have led to increased salinity at Lake Qarun (70 km south-west of Cairo near the Nile), leading to increasing numbers of Slender-billed Gulls at this inland site (Goodman & Meininger 1989), and this is possibly a factor in our observations further south in Sudan.

Clamorous Reed Warbler *Acrocephalus stentoreus*
A single mist-netted at Bahri on 4 April 2014 (Fig. 7). Seven days later two birds responded by singing to a recording of Clamorous Reed Warbler song in the same area. In much of its local range this is a resident species (Kennerley & Pearson 2010), making it likely that these birds were also resident, although the trapped individual showed no signs of breeding condition. Breeds on the Red Sea coast of Sudan, and Nikolaus (1987) mentioned a record from beside the Nile just south of the Egyptian border, but there are no records on the Nile from further south. The Red

Figure 7 (right). Clamorous Reed Warbler / Rousserolle stentor *Acrocephalus stentoreus*, Bahri Sewage Ponds, Sudan, 4 April 2014 (Tom Jenner)

Figure 6 (below). Slender-billed Gulls / Goélands railleurs *Larus genei,* Tuti Island, Sudan, 24 February 2012 (Tom Jenner)

Figure 8. Wattled Starlings / Étourneaux caronculés *Creatophora cinerea*, Bahri Sewage Ponds, Sudan, 12 April 2014 (Tom Jenner)

Sea population is *A. s. brunnescens*, while that in Egypt is *A. s. stentoreus* (Kennerley & Pearson 2010). Biometrics of the captured bird were insufficient to establish subspecies, and therefore the origin. Recordings were played at other sites without response. The construction of the Aswan High Dam in Egypt led to an increase in reedbeds, with Clamorous Reed Warblers extending their range along the length of the Nile in Egypt below the dam (Goodman & Meininger 1989).

Wattled Starling *Creatophora cinerea*

Flocks regularly observed at Bahri between mid February and late May throughout the study, with max. *c.*200 in April 2014 (Fig. 8). Flocks included males in full breeding plumage and recently fledged juveniles. We also have records from Soba Hospital (April 2012) and an area beside the Blue Nile *c.*5 km from there (August 2010 and April 2011). Nikolaus (1987) described the species as rare in the north (i.e. within the current boundaries of Sudan) and knew of no breeding records. Our records suggest that it is a locally common resident in Khartoum State and probably breeds at sewage sites or nearby.

Village Weaver *Ploceus cucullatus*

Recorded regularly at Soba Hospital and Bahri sewage ponds throughout the study, where many were mist-netted (Fig. 9). We noted hundreds of nests at Bahri and several breeding colonies around Khartoum State, especially close to the Nile rivers, and we have recorded the species 330 km further north at Karima (18°33'36"N 31°50'28"E), where it was common beside the River Nile on 20 March 2014. The first record for Egypt was reported in May 2006 (Jiguet 2012). Nikolaus (1987) reported no records north of 14ºN, which is

Figure 9. Village Weaver / Tisserin gendarme *Ploceus cucullatus*, Bahri Sewage Ponds, Sudan, 28 February 2014 (Tom Jenner)

south of Khartoum. This is now a common and conspicuous species in Khartoum State and it is unlikely that Nikolaus and others would have missed it, suggesting a recent range expansion.

Conclusion

Many species appear to have undergone significant range expansions, or changed their status, since the publication of Nikolaus (1987), although some of these might have been previously overlooked. Three species that were unknown in Sudan, or known from just a single record, namely Hottentot Teal, Purple Swamphen and Red-knobbed Coot, now have significant resident populations in Khartoum State, while others have increased their ranges or become established as breeding or winter residents. It is worth emphasising that Khartoum State is *c.*400 km from the nearest national border, so in many cases these records involve significant range extensions. It is reasonable to assume that many of these populations would not exist if these man-made sewage habitats were unavailable, as equivalent habitats do not occur naturally in the area.

It is estimated that the current sewage treatment ponds in Khartoum State are insufficient for the region's growing population (Maki 2010); it is therefore probable that more will be constructed. We are currently unaware of any major sewage treatment sites serving the cities further north, but this may change with future development. In addition, other wetland sites could be important; in 2009 a major new dam was built at Merowe, 350 km north of Khartoum, and the Kajbar Dam is planned for further north (Bosshard 2008). A man-made wetland also exists beside Khartoum oil refinery, 70 km north of Khartoum; we have been unable to visit it, but apparently it is an oxidant pond dealing with industrial wastewater (KRCSD 2015).

A number of species have recently been recorded for the first time in Egypt (Jiguet *et al.* 2011, 2012, 2014), including two of those discussed here (Three-banded Plover and Village Weaver). Two recent additions to the Egyptian list were recorded at sewage sites, although neither would have come from Sudan. Jiguet *et al.* (2012) described 'an emerging pattern of vagrancy for Afrotropical species along the southern Nile valley'. Goodman & Meininger (1989) discussed responses of birds to changing environments in Egypt, including how the construction of the Aswan High Dam resulted in the spread of *Phragmites* and *Typha* marshes, leading to the spread of reed-dwelling species such as Purple Swamphen and Clamorous Reed Warbler, right along the Nile below the dam. Our records suggest that many species could be extending their ranges along the River Nile in both directions, utilising man-made habitats, such as sewage ponds. That the relatively small sewage sites at Soba Hospital and Omdurman Islamic University support significant populations of many of these species suggests that small ecosystems could be sufficient to promote such

range extensions. This opens the potential for some non-migratory Afrotropical species to reach the Palearctic region and vice versa.

The number of noteworthy records made by us in relatively few visits highlights the degree to which the region has been under-watched by ornithologists in recent years. There is a need for a systematic study of birds at the wetlands of Sudan, to form a baseline from which any future population changes can be assessed. In particular, there is a need to monitor new man-made habitats such as sewage ponds and reservoirs at other locations along the Nile Valley.

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References

Alsalman, A. S. & Ali, A. E. 2011. Population estimation from high resolution satellite imagery: a case study from Khartoum. *Emirates J. Engineering Res.* 16: 63–69.

BirdLife International. 2014. Important Bird Areas factsheet: Phakalane sewage lagoons, near Gaborone. www.birdlife.org (accessed 10 November 2015).

Bosshard, P. 2008. China's environmental footprint in Africa. *SAIS Working Pap. Afr. Stud.* www.sais-jhu.edu (accessed 10 November 2015).

British Trust for Ornithology (BTO). 2014. BTO breeding status codes. www.bto.org (accessed 10 November 2015).

Cave, F. O. & Macdonald J. D. 1955. *Birds of the Sudan.* Edinburgh: Oliver & Boyd.

Christopher, A. J. 2011. Secession and South Sudan: an African precedent for the future. *S. Afr. Geog. J.* 93: 125–132.

Dewilde, J. 2012. Al Dabbaseen Bridge. birdingsudan.blogspot.com (accessed 10 November 2015).

Dowsett, R. J., Atkinson, P. W. & Caddick, J. A. 2015. Checklist of the birds of Sudan. www.africanbirdclub.org (accessed 10 November 2015).

Glue, D. & Bodenham, D. 1974. Bird-life at a modern sewage farm. *Bird Study* 21: 229–237.

Goodman S. M. & Meininger P. L. (eds.) 1989. *The Birds of Egypt.* Oxford: Oxford University Press.

Jiguet, F., Baha el Din, M., Baha el Din, S., Bonser, R., Crochet, P.-A., Grieve, A., Hoath, R., Haraldsson, T., Riad, A. & Megalli M. 2011. First report of the Egyptian Ornithological Rarities Committee – 2010. www.chn-france.org (accessed 10 November 2015).

Jiguet, F., Baha el Din, M., Baha el Din, S., Bonser, R., Crochet, P.-A., Grieve, A., Hoath, R., Haraldsson, T., Riad, A. & Megalli, M. 2012. Second report of the Egyptian Ornithological Rarities Committee – 2011. www.chn-france.org (accessed 10 November 2015).

Jiguet, F., Baha el Din, S., Abdel Latif Ibrahim, W., Bonser, R., Corso, A., Crochet, P.-A., Grieve, A., Hoath, R. & Schweizer, M. 2014. Third report of the Egyptian Ornithological Rarities Committee – 2012 and 2013. www.chn-france.org (accessed 10 November 2015).

Kennerley, P. & Pearson, D. 2010. *Reed and Bush Warblers.* London, UK: Christopher Helm.

Khartoum Refinery Company. 2015. www.krcsd.com (accessed 10 November 2015).

Maki, A. M. E. 2010. Wastewater management in Khartoum Region: Soba Wastewater Treatment Plant (Stabilization ponds). M.Sc. thesis. Khartoum: Sudan Academy of Science.

Mara, D. 2003. *Domestic Wastewater Treatment in Developing Countries.* London, UK: Earthscan.

Nikolaus, G. 1987. Distribution atlas of Sudan's birds with notes on habitat and status. *Bonn. Zool. Monogr.* 25: 1–322.

Plusquellec, H. 1990. The Gezira Irrigation Scheme in Sudan: objectives, design and Performance. *World Bank Tech. Pap. 120.* Washington DC: The World Bank.

Robertson, P. 2001. Sudan. In Fishpool, L. D. C. & Evans, M. I. (eds.) *Important Bird Areas in Africa and Associated Islands: Priority Sites for Conservation.* Newbury: Pisces Publications & Cambridge, UK: BirdLife International.

Woods, C. & Faki, E. 2012. Ringing on Um Shugeira, March 2012. birdingsudan.blogspot.com (accessed 10 November 2015).

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Appendix 1. Species observed at sewage sites in Khartoum State, Sudan, April 2012–May 2015.

Sequence and taxonomy generally follow Dowsett *et al.* (2015), with amendments.

Sites: S = Soba Hospital; B = Bahri; K = Khartoum; O = Omdurman.

Status: R = Resident at sewage sites; L = Local resident, visiting sewage sites; P = Palearctic winter visitor; A = Afrotropical wet-season visitor; M = Passage migrant.

Encounter rate: *c* = Common (encountered on most visits in season); f = Fairly common (encountered on fewer than 50% of visits in season); u = Uncommon (encountered three times or fewer).

Annexe 1. Espèces d'oiseaux observées sur quatre bassins d'eaux usées à Khartoum, Soudan, avril 2012–mai 2015.

L'ordre et la taxonomie suivent principalement Dowsett *et al.* (2015) avec des amendements.

Sites : S = Hôpital de Soba ; B = Bahri ; K = Khartoum ; O = Omdurman.

Statut : R = Résident sur les bassins d'eaux usées ; L = Résident local, visitant les bassins d'eaux usées ; P = Hivernant d'origine paléarctique ; A = Migrateur afrotropical présent en saison des pluies ; M = Migrateur de passage.

Fréquence d'observation : *c* = commune (observée pendant de la majorité des visites en saison appropriée) ; f = fréquente (observée pendant moins de la moitié des visites en saison appropriée) ; u = peu commune (observée trois fois ou moins).

		Sites	Status	Encounter rate	Comments
PODICIPEDIDAE					
Little Grebe	*Tachybaptus ruficollis*	SBK	RP	c	Breeding in small numbers. Numbers increase in winter. Max. c.500, April.
PHALACROCORACIDAE					
Reed Cormorant	*Phalacrocorax africanus*	SB	L	f	Small numbers, fewer in winter. Max. 5, March.
ARDEIDAE					
Black-crowned Night Heron	*Nycticorax nycticorax*	S	M	u	Single August record; common on passage along both Niles.
Squacco Heron	*Ardeola ralloides*	SBKO	RP	c	Present all year. Breeding not confirmed, though immatures common. Max. c.60, January.
Cattle Egret	*Bubulcus ibis*	SBKO	R	c	Present all year. Colony at Bahri with c.300 nests in wet season.
Striated Heron	*Butorides striata*	B	L	u	Two single May records. Common on the Nile.
Little Egret	*Egretta garzetta*	SBK	R	c	Present all year. Breeding not confirmed. Max. c.20.
Intermediate Egret	*Ardea intermedia*	B	A	u	Small numbers present in wet season. Max. 2.
Great Egret	*Ardea alba*	B	P	u	Single November record. Common locally.
Purple Heron	*Ardea purpurea*	SB	P	f	Scattered records August–April. Max 2.
Grey Heron	*Ardea cinerea*	SBK	P	c	September–May. Max. 42, April.
Black-headed Heron	*Ardea melanocephala*	BK	L	f	Small numbers all year; commoner in wet season. Max. 4.
CICONIIDAE					
African Openbill	*Anastomus lamelligerus*	B	A	u	Single April record: 22 flying over. Common locally in wet season.
Black Stork	*Ciconia nigra*	B	M	u	Singles flying over, January and May.
Abdim's Stork	*Ciconia abdimii*	B	A	f	Wet-season visitor. Max. 5, September.
THRESKIORNITHIDAE					
Glossy Ibis	*Plegadis falcinellus*	SB	P	f	Small numbers winter August–April, major passage along White Nile. Max. 15, December.
Sacred Ibis	*Threskiornis aethiopicus*	SBK	R	c	Small breeding colony at Bahri in wet season; common winter visitor. Max. c.300, February.
PHOENICOPTERIDAE					
Greater Flamingo	*Phoenicopterus roseus*	B	P	u	Single individual present January–May.
ANATIDAE					
Fulvous Whistling Duck	*Dendrocygna bicolor*	SBK	RA	f	All year; commoner in wet season. Max. 40, May.
White-faced Whistling Duck	*Dendrocygna viduata*	SBK	R	c	Common all year; confirmed breeder. Max. c.500, December.
Eurasian Wigeon	*Mareca penelope*	B	P	u	Single record of five, December. Commoner on Nile.

		Sites	Status	Encounter rate	Comments
Northern Pintail	*Anas acuta*	B	P	f	Max. 5, October and November.
Hottentot Teal	*Spatula hottentota*	SBKO	R	c	Breeding confirmed (31 January, Omdurman; 11 February, Khartoum). Max. 48, September.
Garganey	*Spatula querquedula*	SBKO	P	c	August–May, but mainly October–April. Max. c.800, January.
Northern Shoveler	*Spatula clypeata*	SBK	P	c	August–March, but mainly October–March. Max. c.500 January.
Southern Pochard	*Netta erythrophthalma*	BK	A	f	August–March. Max. 11, February.
Ferruginous Duck	*Aythya nyroca*	BK	P	u	Single, September; two, December.
Tufted Duck	*Aythya fuligula*	BK	P	u	Max. 3, November and December.
ACCIPITRIDAE					
Black-shouldered Kite	*Elanus caeruleus*	SB	R	f	Locally common; breeding confirmed.
Yellow-billed Kite	*Milvus migrans parasitus*	SBKO	R	c	Confirmed breeder in small numbers.
Western Marsh Harrier	*Circus aeruginosus*	SBK	P	f	October–March. Max. 4, February.
Gabar Goshawk	*Micronisus gabar*	S	L	f	Single, November.
Long-legged Buzzard	*Buteo rufinus*	BK	L	u	Singles, December and January.
FALCONIDAE					
Lesser Kestrel	*Falco naumanni*	B	P	u	Single, March.
Common Kestrel	*Falco tinnunculus*	B	L	u	Single, December.
Eurasian Hobby	*Falco subbuteo*	O	M	u	Single, May.
Lanner Falcon	*Falco biarmicus*	SBK	L	f	Singles, year-round.
RALLIDAE					
Little Crake	*Zapornia parva*	S	P	u	Two, February. Probably under-recorded.
Common Moorhen	*Gallinula chloropus*	SBKO	R	c	All year; confirmed breeder. Especially common at Khartoum. Max. c.300, February.
Purple Swamphen	*Porphyrio porphyrio*	SBKO	R	c	All year. Immature, September. Max. 8, September. Also 125 near Sunt Forest on White Nile.
Eurasian Coot	*Fulica atra*	B	P	f	November–March. Max. 6, January.
Red-knobbed Coot	*Fulica cristata*	BK	R	c	Mostly at Khartoum. Confirmed breeder; juveniles January and February. Max. 44, January.
ROSTRATULIDAE					
Greater Painted-snipe	*Rostratula benghalensis*	SB	R	f	Singles, February and May.
RECURVIROSTRIDAE					
Black-winged Stilt	*Himantopus himantopus*	SBKO	R	c	All months; possibly breeding. Max. c.130, February.
BURHINIDAE					
Senegal Thick-knee	*Burhinus senegalensis*	BK	R	f	Max. c.30, March.
PLUVIANIDAE					
Egyptian Plover	*Pluvianus aegyptius*	S	L	u	One record of two, September. Common on Nile.
CHARADRIIDAE					
Little Ringed Plover	*Charadrius dubius*	SB	P	f	Max. 5, February.
Common Ringed Plover	*Charadrius hiaticula*	SBKO	R	c	Max. 15, October.
Kittlitz's Plover	*Charadrius pecuarius*	BKO	L	f	Occasional records all months. Max. 8, September.
Three-banded Plover	*Charadrius tricollaris*	S	R	f	Scattered records all year. Max. 2.
Kentish Plover	*Charadrius alexandrinus*	B	P	u	Single, February.
Black-headed Lapwing	*Vanellus tectus*	B	L	u	Single record, July. Commoner further south.
Spur-winged Lapwing	*Vanellus spinosus*	SBKO	R	c	Common breeder; sometimes in larger groups. max. c.100.
White-tailed Lapwing	*Vanellus leucurus*	B	P	f	October–February; small numbers. Max. 4, December.

		Sites	Status	Encounter rate	Comments
SCOLOPACIDAE					
Little Stint	*Calidris minuta*	SBK	P	c	August–April. Max. c.50, April.
Temminck's Stint	*Calidris temminckii*	SBK	P	c	September–April. Max. c.10, March and October.
Curlew Sandpiper	*Calidris ferruginea*	SBK	P	c	September–February. Max. c.10, February.
Ruff	*Calidris pugnax*	SBKO	P	c	August–April. Max. c.2,000, February.
Common Snipe	*Gallinago gallinago*	SBKO	P	f	September–April. Max. 8, February
Black-tailed Godwit	*Limosa limosa*	SBK	P	f	Occasional in small numbers. Max. 4, March. Commoner on Nile.
Spotted Redshank	*Tringa erythropus*	SB	P	f	February–April. Max. 5, February.
Common Redshank	*Tringa totanus*	O	P	u	Single January record.
Marsh Sandpiper	*Tringa stagnatilis*	SBKO	P	c	September–April. Max. c.100, September.
Common Greenshank	*Tringa nebularia*	SK	P	f	August–February. Max. 3, August.
Green Sandpiper	*Tringa ochropus*	SBO	P	f	August–April. Max. c.10, September/October.
Wood Sandpiper	*Tringa glareola*	SBKO	P	c	August–April. Max. c.100 September and December.
Common Sandpiper	*Actitis hypoleucos*	SBK	P	c	August–May. Max. c.10, January and September.
LARIDAE					
Common Black-headed Gull	*Larus ridibundus*	B	M	u	Group of 16, April. Common on passage along White Nile.
Slender-billed Gull	*Larus genei*	B	M	u	One record of two, April. Fairly common on migration on Blue and White Nile.
Gull-billed Tern	*Gelochelidon nilotica*	SB	P	f	October–May. Max. c.5, May.
Whiskered Tern	*Chlidonias hybrida*	SBK	P	c	September–May. Max. c.300, April.
White-winged Tern	*Chlidonias leucopterus*	SBK	P	c	September–May. Max. c.1,000, April.
PTEROCLIDAE					
Chestnut-bellied Sandgrouse	*Pterocles exustus*	S	L	u	Single record of two flying over, February.
COLUMBIDAE					
Namaqua Dove	*Oena capensis*	SBK	R	c	Confirmed breeder in small numbers.
Speckled Pigeon	*Columba guinea*	BK	L	f	October–December.
Rock Dove / Feral Pigeon	*Columba livia*	SBO	L	f	Small numbers at study sites.
African Mourning Dove	*Streptopelia decipiens*	SBKO	R	c	Confirmed breeding at study sites, often in *Acacia* over water.
Laughing Dove	*Spilopelia senegalensis*	SBKO	R	c	Confirmed breeding at study sites.
PSITTACIDAE					
Rose-ringed Parakeet	*Psittacula krameri*	S	L	u	Single record of two flying over, April.
CUCULIDAE					
White-browed Coucal	*Centropus superciliosus*	SBO	R	f	Probably breeding at study sites.
CAPRIMULGIDAE					
Long-tailed Nightjar	*Caprimulgus climacurus*	SBKO	R	f	Probably breeding at study sites.
APODIDAE					
African Palm Swift	*Cypsiurus parvus*	SBKO	R	c	Probably breeding at study sites or locally.
Common Swift	*Apus apus*	BO	M	u	February–March. Max. c.15, February.
Little Swift	*Apus affinis*	B	L	u	Single, December. Local status unclear. Seen at several places in all months, in groups of up to 50. Not reported near Khartoum State by Nikolaus (1987).
COLIIDAE					
Blue-naped Mousebird	*Urocolius macrourus*	SBK	R	c	Probably breeding at study sites.
ALCEDINIDAE					
Pied Kingfisher	*Ceryle rudis*	SB	L	f	Occasional sightings; common locally.

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MEROPIDAE					
Little Bee-eater	*Merops pusillus*	SB	R	c	Probably breeding at study sites in small numbers.
White-throated Bee-eater	*Merops albicollis*	S	A	f	Several sightings, August–October. Wet-season visitor from south.
Little Green Bee-eater	*Merops orientalis*	B	R	f	Confirmed breeding at study sites.
European Bee-eater	*Merops apiaster*	SBO	M	f	April, May and September. Max. *c.*15, September.
UPUPIDAE					
Common Hoopoe	*Upupa epops*	SB	P	f	Occasional, September–March. Max. 2.
BUCEROTIDAE					
Red-billed Hornbill	*Tockus erythrorhynchus*	S	L	u	Single record of two flying over, August.
PICIDAE					
Eurasian Wryneck	*Jynx torquilla*	B	M	u	Single September record.
ALAUDIDAE					
Crested Lark	*Galerida cristata*	SBKO	R	c	Probably breeding at study sites.
Chestnut-backed Sparrow Lark	*Eremopterix leucotis*	SBKO	R	c	Confirmed breeding at study sites in small numbers.
HIRUNDINIDAE					
Plain Martin	*Riparia paludicola*	SK	L	f	Common local resident; occasional visitor to sites. Max. *c.*20, September.
Common Sand Martin	*Riparia riparia*	SBK	M	c	Common passage migrant, September and March–May. Max. *c.*400, April.
Red-rumped Swallow	*Cecropis daurica*	SB	M	u	Single record of two, April.
Ethiopian Swallow	*Hirundo aethiopica*	SBKO	R	c	Probably breeding on study sites. Max. *c.*50, October.
Barn Swallow	*Hirundo rustica*	SBKO	P	c	September–April. Max. *c.*10, April.
Common House Martin	*Delichon urbicum*	SB	P	u	Single, April.
MOTACILIDAE					
Yellow Wagtail	*Motacilla flava*	SBKO	P	c	August–April. *c.*2,000 roosting at Khartoum, February. At sewage sites nearly all are *M. f. feldegg*, whereas the commonest subspecies observed elsewhere is *M. f. beema*.
White Wagtail	*Motacilla alba*	SBKO	P	c	September–May. Max. *c.*10, November and December.
PYCNONOTIDAE					
Common Bulbul	*Pycnonotus barbatus*	SBKO	R	c	Probably breeding at study sites.
TURDIDAE					
Rufous-tailed Scrub Robin	*Cercotrichas galactotes*	S	L	u	Single record of two, April.
Northern Wheatear	*Oenanthe oenanthe*	B	P	f	Single record (several unidentified wheatears probably this species).
Desert Wheatear	*Oenanthe deserti*	S	P	u	Single January record.
Isabelline Wheatear	*Oenanthe isabellina*	S	P	u	Single November record.
CISTICOLIDAE					
Graceful Prinia	*Prinia gracilis*	SBKO	R	c	Probably breeding at study sites.
ACROCEPHALIDAE					
Sedge Warbler	*Acrocephalus schoenobaenus*	SBK	P	c	Dry-season visitor, September–April.
Eurasian Reed Warbler	*Acrocephalus scirpaceus*	SBKO	P	c	Dry-season visitor, September–April.
Great Reed Warbler	*Acrocephalus arundinaceus*	S	P	u	Two records, April and September.
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	R	u	Single mist-netted, April. Two singing the following week. Status uncertain.
Eastern Olivaceous Warbler	*Iduna pallida*	S	L	u	Common local resident, seen twice at Soba.
PHYLLOSCOPIDAE					
Willow Warbler	*Phylloscopus trochilus*	SB	P	f	September, October and April. Max. 3, October.

		Sites	Status	Encounter rate	Comments
Common Chiffchaff	*Phylloscopus collybita*	SB	P	f	November. Max. 5.
SYLVIIDAE					
Lesser Whitethroat	*Sylvia curruca*	S	P	u	Common local winter visitor, three records at study sites
NECTARINIDAE					
Beautiful Sunbird	*Cinnyris pulchellus*	S	L	f	Common local resident; occasional visitor to study sites.
LANIIDAE					
Masked Shrike	*Lanius nubicus*	S	P	u	Single, April. Common locally.
Southern Grey Shrike	*Lanius meridionalis*	B	A	u	Single, August.
Isabelline Shrike	*Lanius isabellinus*	S	P	u	Single, February.
Red-backed Shrike	*Lanius collurio*	S	P	u	Single, October.
STURNIDAE					
Greater Blue-eared Starling	*Lamprotornis chalybaeus*	S	A	f	August–November.
Wattled Starling	*Creatophora cinerea*	SB	R	f	February–May. Probably breeding at study sites or locally. Max. c.200, April.
PASSERIDAE					
House Sparrow	*Passer domesticus*	SBKO	R	c	Several thousand; confirmed breeding.
Sudan Golden Sparrow	*Passer luteus*	SB	L	c	March–May. Max. 80, March.
PLOCEIDAE					
Little Weaver	*Ploceus luteolus*	S	L	u	Single October mist-netting record.
Northern Masked Weaver	*Ploceus taeniopterus*	SBKO	R	c	Abundant breeding resident. Several thousand nests, mainly February–November.
Vitelline Masked Weaver	*Ploceus vitellinus*	B	L	u	Single May mist-netting record.
Village Weaver	*Ploceus cucullatus*	SB	R	c	Several hundred nests at Bahri.
Cinnamon Weaver	*Ploceus badius*	B	L	u	Single sighting. Breeds locally. Three hybrids *P. badius* × *P. taeniopterus* netted. Hybrid building nest, April.
Red-billed Quelea	*Quelea quelea*	SB	L	f	February–May. Occasional visitor. Max. 2.
Northern Red Bishop	*Euplectes franciscanus*	SB	R	c	Confirmed breeding at study sites.
ESTRILDIDAE					
Crimson-rumped Waxbill	*Estrilda rhodopyga*	S	L	f	Common locally; occasional visitor to study sites.
Red-billed Firefinch	*Lagonosticta senegala*	SB	R	c	Probably breeding at study sites in small numbers.
African Silverbill	*Lonchura cantans*	SBK	R	c	Confirmed breeding at study sites in small numbers.
VIDUIDAE					
Pin-tailed Whydah	*Vidua macroura*	S	L	u	Fairly common locally; occasional visitor to study sites.
Village Indigobird	*Vidua chalybeata*	S	L	f	Fairly common locally; occasional visitor to study sites.
FRINGILLIDAE					
White-rumped Seedeater	*Crithagra leucopygia*	S	L	f	Fairly common locally; occasional visitor to study sites.